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(71) Applicant (*for all designated States except US*): NASHUA CORPORATION [US/US]; 44 Franklin Street, Nashua, NH 03061 (US).

(72) Inventor; and
(75) Inventor/Applicant (*for US only*): CLABBURN, Robin [GB/GB]; Buckthorne House, Sevenhampton, Wiltshire SN6 7QA (GB).

(74) Agent: HOWDEN, Christopher, A.; Forrester Ketley & Co., Forrester House, 52 Bounds Green Road, London N11 2EY (GB).

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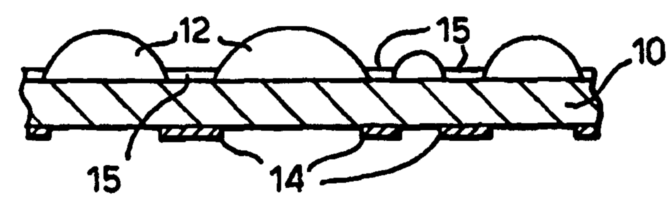
(57) Abstract



Various techniques are disclosed for forming light diffusing or projection screens, comprising printing a transparent substrate. In preferred techniques, resin forming microlenses (12) are deposited on one side of a transparent substrate (10) and an opaque material (14) is deposited on the opposite side so as to cover the areas between lenses (12). In one technique, the substrate is printed with a pattern corresponding to the desired locations of the lenses, in a material wettable by a polymerisable monomer, whilst the substrate is non–wettable by the monomer, or the interstices between desired lens locations are printed in a non–wettable material (the substrate being wettable) and the substrate so printed is coated with the fluid monomer, which adheres preferentially to the wettable regions to form droplets or beads which are subsequently cured to form microlenses. In another technique, (Figure 6), successive layers of fusible transparent toner are deposited on the substrate electrographically. In yet another technique, transparent droplets are "printed" on the substrate (12) by means similar to an "ink–jet" printer.

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REAR PROJECTION SCREEN AND METHODS OF MANUFACTURE THEREOF

THIS INVENTION relates to microlens screens suitable for use as rear projection screens and it is an object of the invention to provide improved-contrast microlens screens and improved methods of manufacturing such screens.

Rear projection screens are known which comprise a regular or irregular array of microlenses or other surface features, the function of which is to scatter light striking the screen from behind, for example in the form of a real optical image projected onto the screen from behind by an appropriate optical projection system, in directions displaced from the original propagation direction, whereby viewers of the screen, on the other side of the screen, who are not located in direct line with the projector, are able to view the image projected thereon. Such screens may also be utilised in, for example, back-lit LCD displays, for example, in portable computers, to spread the light from the light source or sources used for back-lighting and also to allow such screens to be viewed over a range of angular positions displaced from the normal. For convenience, although in the latter case no "projection" is normally involved, screens for this purpose are also referred to herein, and in the claims, as "rear projection" screens.

In the uses of rear projection screens exemplified above, a recognised and long-standing problem is that ambient light, striking the screen from the side of the screen on which the or each viewer is located, is reflected therefrom towards the viewer and reduces the contrast in the perceived image. Known techniques for relieving this contrast-reducing effect, and thus of enhancing

contrast, include arranging a neutral filter in front of the screen, so that ambient light striking the screen and being reflected therefrom is attenuated twice, once on proceeding towards the screen and once again on reflection from the screen, whilst the light passing through the screen from the projecting means, for example, is attenuated only once. Another contrast-enhancing technique consists in covering the regions of the screen between microlenses or analogous light-scattering features with a light-absorbing pigment or medium, so that those portions of the screen which play no part in the desired light-scattering effect likewise contribute nothing to the reflection of ambient light towards the viewer.

Thus, U.S. Patent Specification No. 4636035 discloses a "black stripe" rear projection screen in which a transparent plastics sheet has on its rear surface a first series of parallel cylindrical lenses and has on its front surface a second series of parallel cylindrical lenses, with interposed parallel black stripes with each lens in the first series arranged to concentrate light projected therefrom to pass through the respective lens in the second series without striking the black stripes, which, by absorbing ambient light, provide enhanced contrast. However, such screens are generally manufactured by extrusion of the relevant molten plastics material, so that it is difficult to produce the lens features accurately below a certain size, so that such screens limit the resolution of detail in the images projected thereon. Furthermore, such screens are not well adapted for projection television or video arrangements in which the image source itself comprises regularly spaced rows or rows and columns since Moiré effects are then difficult to avoid. In the interests of reducing weight and cost large projection television systems utilising CRT display devices as the image source utilise Fresnel lens projection optics, again providing a source of Moiré effects in combination with projection screens using regular lens arrays.

It is among the objects of the invention to provide an improved method of manufacturing rear-projection screens of the last-noted type.

According to one aspect of the invention there is provided a rear projection screen comprising a transparent sheet having a plurality of individual bodies of light-transmitting material adhered thereto, said bodies being lenticular in form and thus forming respective lenses, said sheet further having a contrast-enhancing pattern defined by a light-absorbing coating or deposit adhered to said sheet, said pattern comprising an array of apertures or windows in said coating, each said window registering with a said microlens.

According to another aspect of the invention there is provided a method of manufacturing an enhanced-contrast, rear-projection screen comprising a transparent or translucent sheet bearing on one side an array of microlenses and on its opposite side a contrast-enhancing pattern comprising a light-absorbing coating or deposit having apertures or windows each registering with a said microlens, the method comprising providing said transparent or translucent substrate, applying to one side of said substrate an opaque coating or deposit in said contrast-enhancing pattern, and applying to the other side of said substrate a light-transmitting polymer or plastics in a pattern to define said microlenses.

One method according to the invention comprises applying said contrast-enhancing pattern to one side of a transparent or translucent substrate, providing, on the opposite side of said substrate, a pattern of spots, corresponding to said apertures and registering therewith, which are readily wettable by a predetermined settable light-transmitting resin or polymer, in a background or field afforded by a surface which is incompatible with, and thus not readily wettable by, said settable resin or polymer, applying said settable

transparent or translucent resin or polymer, in a fluid state, to said opposite side of said substrate and allowing said polymer or resin to be repelled from said incompatible surface portions to form rounded droplets of such polymer or resin upon said readily wettable spots or regions such that a respective said droplet extends over each said spot, and causing or allowing said droplets to set to form such microlenses.

Another method in accordance with the invention comprises printing on one side of a transparent substrate in a substantially clear medium a succession of prints, each print comprising a pattern consisting of a plurality of individual features, each of said successive patterns corresponding with and registering with the pattern of the previously applied print, whereby each of said features in a said print registers with the corresponding feature of the previous print but may differ in size therefrom, so that the superimposed features of successive said prints together form corresponding three-dimensional features, the method comprising applying said contrast-enhancing pattern to the other side of said transparent substrate in register with said patterns, in said clear medium, on said one side of the transparent medium.

Yet another method in accordance with the invention comprises applying said contrast enhancing pattern to said opposite side of the transparent sheet and applying to said one side of said transparent sheet, by means of a computer-controlled printing device, droplets of molten light-transmitting resin, the control of said device by said computer being such as to direct each said droplet to a respective location on said sheet in register with a respective said aperture in the light-absorbing coating and such that said droplets do not contact with or coalesce with one another on said sheet but adhere to said sheet and solidify in lenticular forms. The contrast-enhancing pattern may also, if

desired, be applied by a computer-controlled printing device using opaque ink or other medium applied in the form of a jet or train of droplets.

Embodiments of the invention are described below by way of example, with reference to the accompanying drawings in which:-

FIGURE 1 is a schematic plan view, to a greatly enlarged scale, of a fragment of a rear projection screen in accordance with the invention,

FIGURE 2 is a schematic sectional view of a fragment of the screen of Figure 1,

FIGURES 3, 4 and 6 are view, similar to Figure 2, showing the products of variant methods in accordance with the invention,

FIGURE 5 is a schematic diagram illustrating a method in accordance with the invention,

FIGURE 7 is a fragmentary view, partly in section and partly in perspective, showing a portion of a further screen embodying the invention, and

FIGURE 8 is a schematic sectional view, similar to Figures 2, 3 and 4, of a fragment of a variant of the screen of Figure 2.

In the embodiments of the invention to be described, a rear projection screen comprises a transparent or translucent sheet provided on one surface thereof with an array of microlenses or other surface relief features adapted for light scattering, with a matching contrast-enhancing pattern or mask formed on either the reverse surface or, less preferably, on the same surface as that

provided with the microlens array, the configuration of the contrast-enhancing mask corresponding with and being in register with the microlens or other surface feature array so that the mask provides apertures or windows for the transmission of light, in the direction approximately normal to the plane of the material, through the corresponding microlenses or light-scattering features but provides an opaque barrier to the passage of light through the regions between such microlenses or analogous features. In some arrangements, the microlenses may be circular or elliptical lenses disposed in a regular array of rows and columns with planar regions of the transparent sheet material extending between and around the microlenses, whilst the contrast-enhancing mask may comprise a layer of opaque (preferably black) pigment extending across the opposite surface of the sheet and having apertures or windows therein, each aperture or window corresponding to and being aligned with a respective one of said microlenses. However, particularly with a view to reducing Moiré effects and to allow a close packing density of microlenses to be achieved, it is preferred that the microlenses or other light-scattering features be disposed in a substantially random or pseudo-random array, with the microlenses being of various different sizes and possibly shapes (e.g. hexagonal, square or oblong), distributed at random, with the apertures or windows in the mask being correspondingly arrayed, but nevertheless with each window being in register with its corresponding microlens. Thus, for example, both the microlens array and the mask may be derived from the same "master" random feature array, allowing full alignment and registration between the mask and the microlens array whilst maintaining the random character thereof.

Referring to Figures 1 and 2 there are illustrated schematically, to a greatly increased scale, a fragment of an enhanced-contrast rear projection screen manufactured in accordance with the invention. This screen comprises a transparent substrate or base layer 10, for example of transparent plastics such

as "Mylar" polyester film bearing on one side surface formations, herein referred to as lenses, indicated at 12 and which are formed from a transparent or translucent medium, such as a transparent polymer, adhered to the surface of the film 10, the sheet 10 bearing on its opposite surface an opaque deposit 14 forming a pattern complementary with the pattern formed by the microlenses 12 such that, as viewed perpendicular to the plane of the screen, the opaque deposit 14 provides an opaque field in which is disposed an array of apertures or windows each corresponding with and registering with a respective one of the microlenses 12. Thus, as illustrated in Figure 1, the screen may be regarded as opaque except in the regions of the microlenses 12, (which, however, form the greater part of the area of the screen).

It should be noted that, to avoid Moiré effects, it is preferred that the microlenses 12 should not be of uniform size and arranged in a regular array. Rather, it is preferred that the microlens size varies from microlens to microlens in a random manner and that the microlenses themselves are randomly distributed. Such an arrangement has the added advantage of allowing a closer packing ratio than is possible with lenses of uniform size arrayed regularly. Whilst, as illustrated, the microlenses are of circular form as viewed perpendicular to the plane of the screen (Figure 1), they may be of other shapes, for example elongated shapes such as oval or ellipsoidal (or even hexagonal, square or oblong) and where the microlenses are thus elongate, they may be arranged with their axes of elongation (major axes) extending in a common direction in the plane of the screen or having major components extending in such common direction whereby the light-scattering or diffusing characteristics of the screen are rendered asymmetric, that is to say whereby the screen will operate to scatter light through a wider angle in one direction (usually the horizontal direction) than in another direction, (for example the vertical direction). It will also be appreciated that the individual lenses need

not be of any regular geometrical shape, since the purpose of the microlenses is to scatter light in essentially random directions. Thus, the individual shapes of the "microlenses" may themselves be random in character.

It will be appreciated that it is not essential for each aperture or "window" in the opaque deposit 14 to be of the same size as its corresponding microlens. Indeed, contrast may be enhanced by deliberately making these apertures smaller than their corresponding microlenses, as indicated in Figures 3 and 8, so that when the screen is utilised as a rear projection screen with the lenses 12 on the side of the screen facing the projector, each lens 12 will, by its focusing action concentrate the light projected on the lens to pass through the respective aperture or window, to diverge beyond the screen. This effect is illustrated in Figure 8, where the lines incorporating arrows or chevrons represent rays of light, from a projection system, passing through the screen. In this way, without an equivalent loss of image light or perceived image brightness a larger percentage of the screen area presented to the ambient light may be made light absorbing, with a correspondingly reduced tendency to reflect ambient light. Thus, for example, as much as 50% of the area of the screen may be covered by opaque deposit 14 whilst a much higher percentage of the screen area remains covered by the microlenses.

As noted above, to ensure correct registration between the microlenses 12 and the apertures in the opaque layer or deposit 14 both the microlens array and the array of apertures in the deposit 14 may be derived from the same "master" random feature array. The different sizes of the individual microlenses, relative to the corresponding apertures in deposit 14, where such difference is present, may be achieved by techniques known *per se*, for example by photographic and/or etching techniques resulting in a secondary, lens array mask in which the "lens" features are larger as compared with the

master and a secondary aperture array mask in which the "lens" feature are smaller, as will be apparent to those skilled in the art.

It will be appreciated from the above that in the preferred embodiments of the invention, the spaces between adjoining microlenses will generally be smaller than indicated in Figures 1 to 4 and 6 and the windows in the opaque deposit smaller, in relation to the gaps between windows, than indicated in these Figures.

In a further variant of the invention, the microlenses 12 are in the form of cylindrical lenses, of indefinite length (for example each extending from edge to edge of the screen) and extending parallel or substantially parallel with one another, for example as illustrated in Figure 7, but preferably of different widths and/or spacings to minimise Moiré effects.

In accordance with a further optional feature, a screen embodying the invention, in accordance with any of the examples discussed above may incorporate a further light diffusing layer. Thus, for example, as illustrated in Figure 8, a light diffusing layer 17, for example a layer 17 of light-diffusing plastics, may be applied to the side of the substrate 10 carrying the opaque deposit 14, preferably covering the deposit 14 as well as the windows or openings therein. The light diffusing layer 17 may be constituted in any of a number of ways, known *per se* and may have asymmetrical light diffusing properties. Alternatively, where, as in the embodiment of Figure 7, the basic screen structure is such as to have possibly excessive symmetry in its light scattering or diffusing properties, the layer 17 may serve to moderate that a symmetry to a controlled extent, for example by scattering light in directions with components parallel with the strip-like cylindrical lenses. The diffusing layer 17 also serves to increase the angle of view (a measure of the extent to

which the screen scatters or "spreads" the light projected onto it). Such a light-diffusing layer 17 may also reduce or eliminate any Moiré effects which may tend to occur, for example with certain projected images. It will be understood that such a light-diffusing layer may be applied to the screen also in the variants referred to below in which no contrast-enhancing mask is present, the diffusing layer in these cases being applied directly to the surface of the substrate remote from the lens formations, for example.

By way of non-limiting example, in embodiments of the invention the substrate 10 may be 1 to 2 mm thick, the lenses 12 may have a mean diameter of 15 to 50 μm and the apertures or windows in the opaque layer 14 might have a mean diameter of 10 to 30 μm, i.e. of approximately two thirds of the diameter of the corresponding lenses. The optimum thickness of the diffusion layer 17 depends to some extent upon its diffusion characteristics but might typically be 50 to 250 μm. The thickness of the opaque layer 14 need only be sufficient to achieve the desired light-absorbing properties, but might be 5 to 10 μm.

Various methods of making a screen of the kind illustrated in Figures 1 and 2 are discussed below.

In one embodiment of the invention, known printing techniques are utilised to print, on one side of the Mylar sheet 10, the appropriate mask 14 defining the appropriate random apertures. The reverse surface of the Mylar sheet 10 is then coated with a photopolymerisable material, (for example polymerisable using ultra-violet light) which has good adhesion to the Mylar substrate, exposing the photopolymerisable material to ultra-violet light through the deposited mask 14 to cure the material in regions corresponding to the apertures in the mask 14, but with each such area being slightly larger in size

than the respective aperture in the mask 14, (due to a certain "spread" in the polymerisation and/or divergence of the UV light used for exposure). The unpolymerised material is then removed, e.g. washed away using an appropriate solvent, in manner known *per se,* leaving the photopolymer extending substantially over only the apertures in the masking layer 14 and thus forming an array of "patches" of the photopolymer. The photopolymer-treated surface of the film then has applied thereto a second liquid polymerisable material which does not wet the substrate 10 but does wet the previously applied photopolymer. As a result of surface tension effects, the film of said second liquid polymerisable material breaks up into droplets each droplet extending over and corresponding in boundary exactly to the respective "patch" of photopolymer, each droplet having a domed shape as a result of surface tension and thus forming a lens. The second material is then polymerised, either by exposure to appropriate polymerising radiation, or thermally, or by chemical action. (In the latter instance the liquid applied to selectively wet the patches of previously applied photopolymer may contain, for example, a suitable monomer or mixture of monomers plus an appropriate catalyst or an appropriate catalyst may be incorporated in the first-applied polymer). The resulting structure is illustrated in Figure 3, where the reference 15 indicates the initially applied photopolymer.

In a variation of the above-noted method, the Mylar substrate 10 is initially coated with a photo-sensitive material which adheres to the Mylar but which is not readily wetted by the second polymerisable material, the photo-sensitive material being of the type which can be modified by exposure to, for example, ultra-violet light, so as to be rendered soluble in a solvent in which the material not so modified is insoluble. In this variant, the photo-sensitive material is then exposed to ultra-violet light through the mask 14, the modified material then washed in the appropriate solvent to remove the areas over the

apertures in the mask and thereafter, after drying the solvent, the second material applied, the second material in this case being one which readily wets the Mylar substrate but not the photoresist remaining over the black areas of the mask, thereby yielding a structure similar to that illustrated in Figure 4, where reference 15 again indicates the initially applied photopolymer. In a further variant of the invention, where a contrast-enhancing mask is not required in the finished product, the opaque mask may be removed at some stage after exposure of the photopolymer, which may, for example, be conveniently done by forming the opaque mask as, or as part of a separate sheet having its own structural integrity and which is removably applied to the surface of the Mylar substrate remote from that bearing the photo-sensitive material, so that it can be subsequently stripped therefrom after exposure of the photo-sensitive material.

It will be understood that in the above-noted embodiments, the opaque masking layer 14, which is preferably black, may be applied by a conventional printing technique, or by an electrographic technique, (as defined below and known *per se*), or by photographic techniques. Indeed, it will be understood that the techniques described above, using photopolymers to establish the division of the substrate into wettable and non-wettable regions are proposed primarily to ensure good registration with the contrast-enhancing mask. Where other printing techniques are or become available which will allow corresponding patterns to be printed in sufficiently close register on opposite sides of a single sheet, such printing techniques may be used to apply a "wettable" or a "non-wettable" medium in the appropriate pattern, without using photopolymers.

It will be understood that the techniques described above are equally applicable to the production of a screen comprising a lenticular array in the form of an array of cylindrical or quasi-cylindrical lenses, such as illustrated in

Figure 7. Thus, for example, in the manufacture of such a screen, the substrate 10 may be marked out or printed with a series of hydrophobic or hydrophilic lines or stripes (i.e. lines or stripes respectively unwettable or wettable by the synthetic resin to be applied (the substrate being respectively wettable or unwettable)).

In another embodiment of the invention, a thermal printer analogous in operation to an ink-jet printer is utilised to create the desired microlenses on the Mylar substrate 10. Such a thermal printer may use a piezo-electric driver to fire droplets of molten plastics onto a substrate on which the molten plastics adheres and solidifies. In this embodiment, each droplet reaching the substrate preferably forms a respective part-spherical globule on the substrate to form a single respective microlens and the apparatus operates to deposit an array of such part-spherical globules upon the substrate, the arrangement preferably being such that the individual globules are spaced from one another and thus do not coalesce. In this arrangement, the positioning of the individual globules is controlled by a computer controlling the printer. The technique used may be similar to that disclosed in the paper "Microjet Fabrication of Microlens Arrays" by D.L. MacFarlane *et al*, IEEE Photonics Technology Letters, Vol. 6, No. 9. (September 1994). The masking layer 14 may have been previously applied to the reverse surface of the Mylar film 10 and may be "read" utilising an appropriate optical reader coupled with the computer controlling the ink-jet printer, the computer operating to direct the thermal printer to deposit the drops of molten plastics in the locations of the apertures or windows in the masking layer. It will be appreciated that where a contrast enhancing mask is not required, the masking layer may be omitted, the computer-controlled printing device being, for example, controlled entirely by a pre-set program, without reference to features of such mask.

In a further embodiment of the invention, both the masking layer 14 and the microlenses are formed by an electrographic technique, (i.e. a process in which, a drum is selectively electrostatically charged and particles of toner, i.e. finely divided thermoplastics material, are adhered electrostatically to the selectively charged region, a sheet to be printed being thereafter placed in rolling contact with the drum to transfer the toner from the drum to the sheet and the toner thereafter fused thermally or by infra-red radiation to cause it to bond intimately to the sheet. In such an electrographic technique, the pattern of electrostatic charge on such drum is generally defined photographically, for example by providing the drum with a coating of a light-sensitive semi-conductor on which an image of the desired pattern is focused optically or is defined by scanning laser, for example. Such techniques are well known, being utilised in photocopiers and laser printers, for example. In carrying out the present invention, in this embodiment, the sheet to be printed takes the form of a continuous Mylar web, indicated at 10 in Figure 5, which is passed, in the direction indicated by the arrows, through apparatus providing a plurality of electrostatic printing stations indicated schematically at A to E in Figure 5. At each of stations A, C, D and E illustrated, the upper surface of the sheet 10 is printed with an array of minute spots or patches of a transparent "toner", each of stations A, C, D and E being arranged to print on the sheet 10 an array of patches of transparent toner which is identical with the array printed by the preceding such station except that, optionally, the individual patches in successively printed arrays may be slightly smaller than the corresponding patches in the preceding array so that, as illustrated in Figure 6, schematically, the superimposed spots of the successive arrays form, at each location concerned, a lens-like structure. It will be appreciated that, in practice, because the toner is fused at each station, the pronounced step effect illustrated in Figure 6 is absent or much attenuated, the stepping being illustrated in Figure 6 in the way in which it is purely for purposes of illustration. At a printing

station B which cooperates with the underside of the Mylar web 10, a complementary pattern is similarly electrographically printed using a black toner 14, so that as illustrated in Figure 6, the black toner is again absent in apertures or windows corresponding in location with the lenses on the upper side of the substrate. The apparatus of Figure 5 is, of course, arranged to provide, on the continuous web 10, a whole series of substantially identical panels, e.g. rectangular panels, each having an array of superimposed clear toner lenses on one side and an aperture mask 14 on the other side. The apparatus used may be an apparatus known *per se* which is capable of applying accurately registering successive patterns to a continuous web. Such accuracy is, in practice, achievable with the assistance of techniques whereby, for example, a marking applied to the edge of the web in one station is monitored by reading means or optical sensors in one or more downstream positions to control the operation of the downstream printing stations. As with the previously described techniques, the above-described technique using electrographic printing may be utilised in the production of a "microlens" diffusion or rear projection screen without a contrast-enhancing mask. The only modification required to this end to the electrographic method described above is the omission of the printing station B for printing black toner.

Again, the above described thermal printer and electrographic printing techniques may, of course, also be used to produce a screen such as shown in Figure 7 comprising a series of elongate cylindrical lenses, the thermal printer being arranged to apply the droplets of molten thermoplastics to the substrate with a spacing small enough to allow successive droplets to contact and coalesce to form a continuous band or stripe. Where, alternatively, the electrographic technique is used, of course, the apparatus may simply be arranged to print superimposed bands of clear toner, rather than individual spots and corresponding continuous bands for the masking toner.

CLAIMS

1. A rear projection screen comprising a transparent sheet having a plurality of individual bodies of light-transmitting material adhered thereto, said bodies being lenticular in form and thus forming respective lenses, said sheet further having a contrast-enhancing pattern defined by a light-absorbing coating or deposit adhered to said sheet, said pattern comprising an array of apertures or windows in said coating, each said window registering with a said lens.

2. A screen according to claim 1 wherein said individual bodies of light-transmitting material are adhered to one side of said transparent sheet and said contrast enhancing pattern is applied to the opposite side of said sheet.

3. A screen according to claim 1 or claim 2 wherein said lenticular bodies are in the form of bands or stripes forming cylindrical lenses of indefinite length and said apertures or windows are in the form of correspondingly continuous light-transmitting bands or slots.

4. A screen according to claim 1 or claim 2 including a light-diffusing layer applied over said light-absorbing coating or deposit.

5. A screen according to claim 4 wherein said light-diffusing layer is asymmetrically diffusive.

6. A method of manufacturing an enhanced contrast rear projection screen comprising a transparent or translucent sheet bearing on one side an array of microlenses and on its opposite side a contrast-enhancing pattern comprising a light-absorbing coating or deposit having apertures or windows each registering

with a said microlens, the method comprising providing said transparent or translucent substrate, applying to one side of said substrate an opaque coating or deposit in said contrast-enhancing pattern, and applying to the other side of said substrate a light-transmitting polymer or plastics in a pattern to define said microlenses.

7. A method of manufacturing an enhanced contrast, rear projection screen comprising a transparent or translucent sheet bearing on one side an array of microlenses and on its opposite side a contrast-enhancing pattern comprising a light-absorbing coating or deposit having apertures or windows each registering with a said microlens, the method comprising applying said contrast-enhancing pattern to one side of a transparent or translucent substrate, providing, on the opposite side of said substrate, a pattern of spots, corresponding to said apertures and registering therewith, which are readily wettable by a predetermined settable light-transmitting resin or polymer, in a background or field afforded by a surface which is incompatible with, and thus not readily wettable by, said settable resin or polymer, applying said settable transparent or translucent resin or polymer, in a fluid state, to said opposite side of said substrate and allowing said polymer or resin to be repelled from said incompatible surface portions to form rounded droplets of such polymer or resin upon said readily wettable spots or regions such that a respective said droplet extends over each said spot, and causing or allowing said droplets to set to form such microlenses.

8. A method according to claim 7 wherein said pattern of spots which are readily wettable is provided by a photographic technique, utilising said light-absorbing coating as an optical mask.

9. A method according to claim 8 wherein said transparent substrate, or said opposite surface thereof is incompatible with and is thus not readily wettable by, said resin or polymer, and wherein the method includes applying to said opposite side a layer of a photo-resist or photopolymer, exposing the last-mentioned layer to radiation of the appropriate wavelength through said optical mask, and developing said layer of photo-resist or photopolymer to expose the portions of said substrate which are in register with the opaque regions of said light-absorbing coating, said photo-resist or photopolymer being wettable by said settable resin or polymer whereby after application of the latter, said settable resin or polymer wets, and adheres to, said photo-resist or photopolymer.

10. A method according to claim 8 wherein said transparent substrate, or said opposite side thereof, is wettable by said resin or polymer and wherein the method includes applying to said opposite side a layer of a photo-resist or photopolymer which is incompatible with, and not readily wettable by said resin or polymer, exposing the photo-resist or photopolymer to radiation of the appropriate wavelength through said optical mask and developing said photopolymer or photo-resist layer to remove the photo-resist from the regions corresponding to and registering with said apertures or windows, whereby after applying said settable resin or polymer to the side of the assembly carrying the photo-resist, the settable resin or polymer wets, and adheres to, said exposed spots of said substrate but is repelled from the adjoining photo-resist coated regions.

11. A method according to claim 7, wherein said pattern of spots is provided by a printing or electrostatic transfer process, in which a medium incompatible with, and not readily wettable by the subsequently applied settable resin or polymer is applied over the regions of said substrate from which the settable

resin is to be repelled, the adjoining surface of said substrate being readily wettable by said resin.

12. A method according to claim 7 wherein said pattern of spots is provided by a printing or electrostatic transfer process in which a medium which is compatible with, and readily wettable by said settable resin is applied in a pattern of spots corresponding to and registering with said apertures or windows, said substrate, or said opposite surface thereof, being incompatible with, and adapted to repel, said settable resin or polymer.

13. A method of manufacturing an enhanced contrast, rear projection screen comprising a transparent or translucent sheet bearing on one side an array of microlenses and on its opposite side a contrast-enhancing pattern comprising a light-absorbing coating or deposit having apertures or windows each registering with a said microlens, the method comprising printing on one side of a transparent or translucent substrate in a light-transmitting medium a succession of prints, each print comprising a pattern consisting of a plurality of individual features, each of said successive patterns corresponding with and registering with the pattern of the previously applied print, whereby each of said features in a said print registers with the corresponding feature of the previous print but may differ in size therefrom, whereby the superimposed features of successive said prints together form corresponding three-dimensional features, the method comprising applying said contrast-enhancing pattern to the other side of said transparent or translucent substrate in register with said patterns, in clear medium, on said one side of the transparent medium.

14. The method according to claim 13 wherein said transparent substrate is in the form of a continuous web fed lengthwise through printing apparatus which applies the respective said patterns successively to said substrate, in

register with one another, at printing stations in said apparatus passed through in succession by said web.

15. A method of manufacturing an enhanced contrast, rear projection screen comprising a transparent or translucent sheet bearing on one side an array of microlenses and on its opposite side a contrast-enhancing pattern comprising a light-absorbing coating or deposit having apertures or windows each registering with a said microlens, the method comprising applying said contrast enhancing pattern to said opposite side of the transparent sheet and applying to said one side of said transparent sheet, by means of a computer-controlled printing device, droplets of molten light-transmitting resin, the control of said device by said computer being such as to direct each said droplet to a respective location on said sheet in register with a respective said aperture in the light-absorbing coating and such that said droplets do not contact with or coalesce with one another on said sheet but adhere to said sheet and solidify in lenticular forms.

16. A rear projection screen made by the method of any of claims 6 to 15.

17. A method of manufacturing a rear projection screen or diffuser comprising a transparent or translucent sheet bearing on one side an array of microlenses, the method comprising providing said transparent or translucent substrate, and applying to one side of said substrate a light-transmitting polymer or plastics in a pattern to define said microlenses.

18. A method of manufacturing a rear projection screen or diffuser comprising a transparent or translucent sheet bearing on one side an array of microlenses, the method comprising providing, on one side of said substrate, a pattern of spots which are readily wettable by a predetermined settable light-transmitting resin or polymer, in a background or field afforded by a surface

which is incompatible with, and thus not readily wettable by, said settable resin or polymer, applying said settable transparent or translucent resin or polymer, in a fluid state, to said one side of said substrate and allowing said polymer or resin to be repelled from said incompatible surface portions to form rounded droplets of such polymer or resin upon said readily wettable spots or regions such that a respective said droplet extends over each said spot, and causing or allowing said droplets to set to form such microlenses.

19. A method according to claim 18 wherein said pattern of spots which are readily wettable is provided by a photographic technique, utilising an optical mask.

20. A method according to claim 19 wherein said transparent substrate, or said opposite surface thereof is incompatible with and is thus not readily wettable by, said resin or polymer, and wherein the method includes applying to said one side a layer of a photo-resist or photopolymer, exposing the last-mentioned layer to radiation of the appropriate wavelength through an optical mask, and developing said layer of photo-resist or photopolymer to expose the portions of said substrate which are in register with the opaque regions of said mask, said photo-resist or photopolymer being wettable by said settable resin or polymer whereby after application of the latter, said settable resin or polymer wets, and adheres to, said photo-resist or photopolymer.

21. A method according to claim 19 wherein said transparent substrate, or said one side thereof, is wettable by said resin or polymer and wherein the method includes applying to said one side a layer of a photo-resist or photopolymer which is incompatible with, and not readily wettable by said resin or polymer, exposing the photo-resist or photopolymer to radiation of the appropriate wavelength through an optical mask and developing said

photopolymer or photo-resist layer to remove the photo-resist from the regions corresponding to and registering with apertures or windows in said mask, whereby after applying said settable resin or polymer to the side of the assembly carrying the photo-resist, the settable resin or polymer wets, and adheres to, said exposed spots of said substrate but is repelled from the adjoining photo-resist coated regions.

22. A method according to claim 18, wherein said pattern of spots is provided by a printing or electrostatic transfer process, in which a medium incompatible with, and not readily wettable by the subsequently applied settable resin or polymer is applied over the regions of said substrate from which the settable resin is to be repelled, the adjoining surface of said substrate being readily wettable by said resin.

23. A method according to claim 18 wherein said pattern of spots is provided by a printing or electrostatic transfer process in which a medium which is compatible with, and readily wettable by said settable resin is applied in a pattern of spots corresponding to and registering with said apertures or windows, said substrate, or said one surface thereof, being incompatible with, and adapted to repel, said settable resin or polymer.

24. A method of manufacturing a projection screen or diffuser comprising a sheet bearing on one side an array of microlenses, the method comprising printing on one side of a transparent or translucent substrate in a light-transmitting medium a succession of prints, each print comprising a pattern consisting of a plurality of individual features, each of said successive patterns corresponding with and registering with the pattern of the previously applied print, whereby each of said features in a said print registers with the corresponding feature of the previous print but may differ in size therefrom,

whereby the superimposed features of successive said prints together form corresponding three-dimensional features.

25. The method according to claim 24 wherein said transparent substrate is in the form of a continuous web fed lengthwise through printing apparatus which applies the respective said patterns successively to said substrate, in register with one another, at printing stations in said apparatus passed through in succession by said web.

26. A method of manufacturing a projection screen or diffuser comprising a sheet bearing on one side an array of microlenses, the method comprising applying to said one side of said transparent sheet, by means of a computer-controlled printing device, droplets of molten light-transmitting resin, such that said droplets do not contact with or coalesce with one another on said sheet but adhere to said sheet and solidify in lenticular forms.

27. A method of manufacturing a rear projection screen, substantially as hereinbefore described in any of the examples herein.

Fig.1.

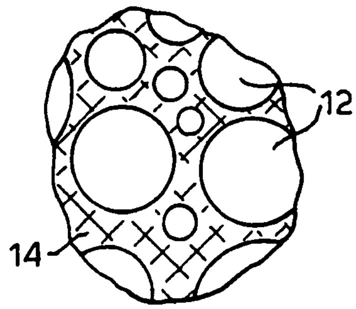


Fig.2.

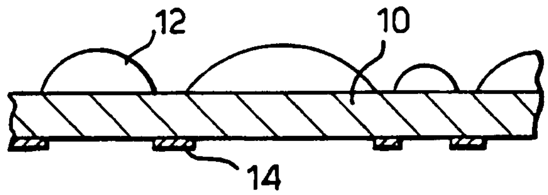


Fig.3.

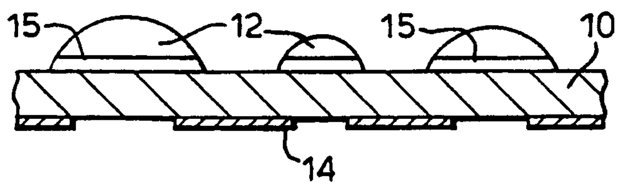


Fig.4.

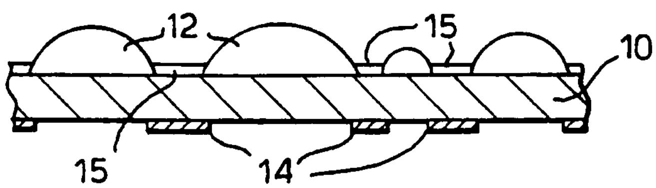


Fig.5.

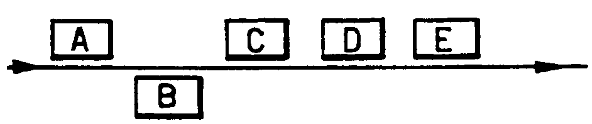


Fig.6.

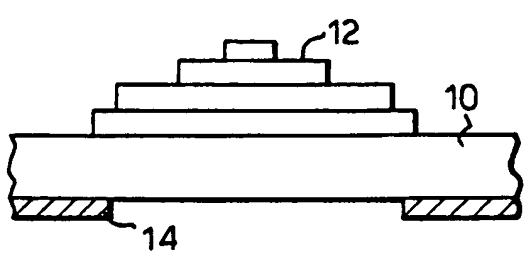


Fig.7.

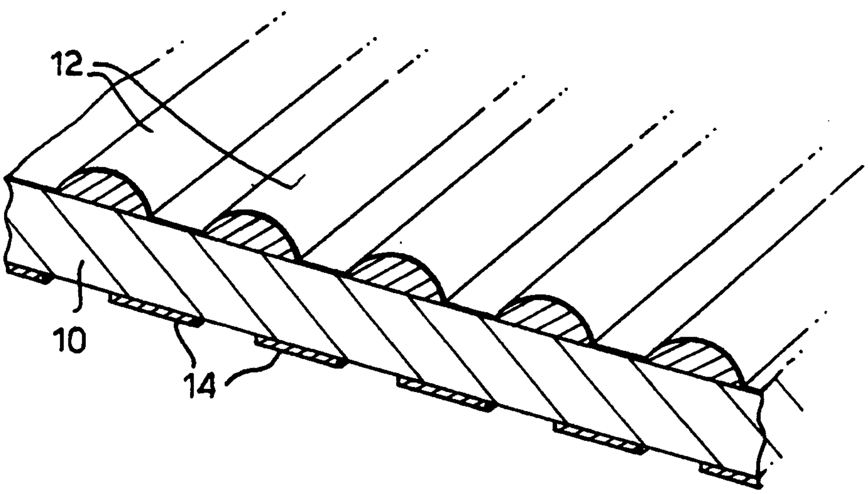
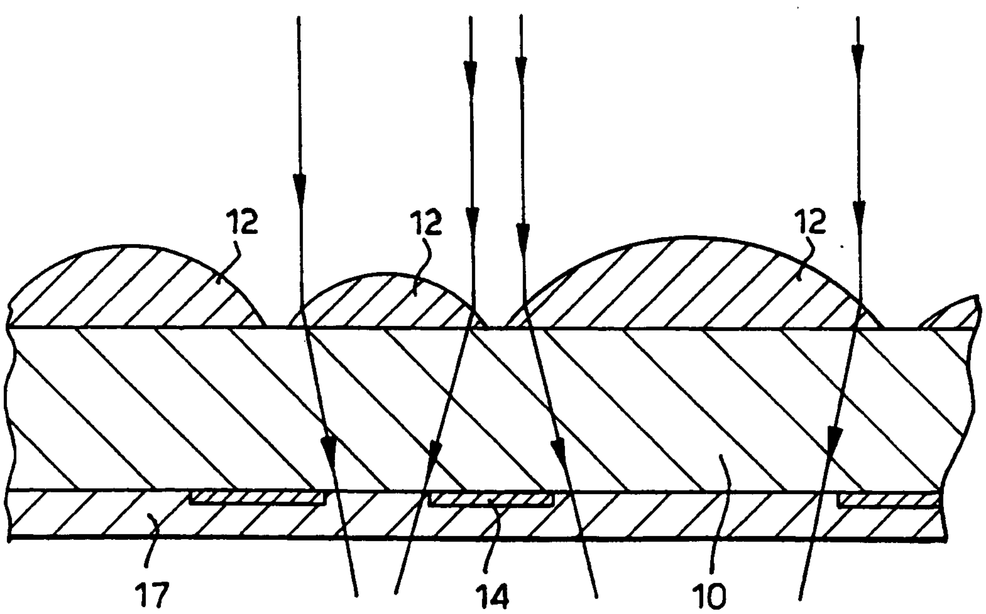


Fig.8.



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INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

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(71) Applicant *(for all designated States except US)*: NASHUA CORPORATION [US/US]; 44 Franklin Street, Nashua, NH 03061 (US).

(72) Inventor; and
(75) Inventor/Applicant *(for US only)*: CLABBURN, Robin [GB/GB]; Buckthorne House, Sevenhampton, Wiltshire SN6 7QA (GB).

(74) Agent: HOWDEN, Christopher, A.; Forrester Ketley & Co., Forrester House, 52 Bounds Green Road, London N11 2EY (GB).

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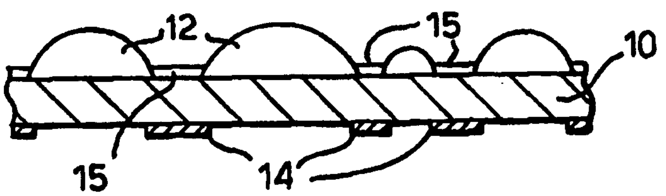
(88) Date of publication of the international search report: 30 September 1999 (30.09.99)

(54) Title: REAR PROJECTION SCREEN AND METHODS OF MANUFACTURE THEREOF

(57) Abstract



Various techniques are disclosed for forming light diffusing or projection screens, comprising printing a transparent substrate. In preferred techniques, resin forming microlenses (12) are deposited on one side of a transparent substrate (10) and an opaque material (14) is deposited on the opposite side so as to cover the areas between lenses (12). In one technique, the substrate is printed with a pattern corresponding to the desired locations of the lenses, in a material wettable by a polymerisable monomer, whilst the substrate is non–wettable by the monomer, or the interstices between desired lens locations are printed in a non–wettable material (the substrate being wettable) and the substrate so printed is coated with the fluid monomer, which adheres preferentially to the wettable regions to form droplets or beads which are subsequently cured to form microlenses. In another technique, (Figure 6), successive layers of fusible transparent toner are deposited on the substrate electrographically. In yet another technique, transparent droplets are "printed" on the substrate (12) by means similar to an "ink–jet" printer.

INTERNATIONAL SEARCH REPORT

Interna...nal Application No
PCT/GB 99/00085

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 G03B21/62 G02B3/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 G03B G02B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 1 942 841 A (TAKEO SHIMIZU) 9 January 1934 (1934-01-09) page 1, line 42 - line 82 page 2, line 46 - line 58 page 2, line 88 - line 105 figures 1,1A,3	1,2,4-6, 17
Y		3

X	US 5 563 738 A (VANCE DENNIS W) 8 October 1996 (1996-10-08) column 9, line 5 - line 29; figure 8	1
A		2-6

Y	US 4 927 233 A (NAKANISHI YASUAKI ET AL) 22 May 1990 (1990-05-22) figures 3-5	3

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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
27 May 1999	6 August 1999

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Aratari, R

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INTERNATIONAL SEARCH REPORT

Intern nal Application No
PCT/GB 99/00085

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	PATENT ABSTRACTS OF JAPAN vol. 015, no. 023 (P-1155), 18 January 1991 (1991-01-18) -& JP 02 266301 A (DAINIPPON PRINTING CO LTD), 31 October 1990 (1990-10-31) abstract -----	

6

Form PCT/ISA/210 (continuation of second sheet) (July 1992)

International application No.
PCT/GB 99/00085

INTERNATIONAL SEARCH REPORT

Box I Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)

This International Search Report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:
See additional sheets.

2. ☐ Claims Nos.:
because they relate to parts of the International Application that do not comply with the prescribed requirements to such an extent that no meaningful International Search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

1. ☐ As all required additional search fees were timely paid by the applicant, this International Search Report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this International Search Report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☒ No required additional search fees were timely paid by the applicant. Consequently, this International Search Report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest.

☐ No protest accompanied the payment of additional search fees.

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 206

Claims Nos.: 16, 27

Claim 27 does not meet the requirement of Rule 6.2(a) PCT.

Claims Nos.: 16

Claim 16 attepts to define a rear projection screen solely by the method used to produce it, namely a method according to any of claims 6-15. Explicitely searching the subject matter of claim 16 is therefore not necessary, since this would exactly correspond to searching the subject matter of claims 6-15. As stated in the Supplemental Sheet B, the claims 6-15 do not meet the requirement of unity of the invention.

This International Searching Authority found multiple (groups of) inventions in this international application, as follows:

1. Claims: 1-6, 17

   Rear projection screen with a transparent sheet, a pluralitiy of indivudual microlenses adhered to one side thereof and a contrast-enhancing light absorbing layer having apertures registering with said microlenses, the microlenses having the shape of cylindrical lenses and the apertures having the shape of continuous slots.

2. Claims: 7-12, 18-23

   Method of manufacturing individual microlenses on a rear projection screen sheet in register with apertures provided in a contrast-enhancing light absorbing layer, by providing on the sheet a plurality of spots with are wettable by a settable polymer, the surface serrounding the spots being not wettable by said polymer.

3. Claims: 13-14, 24-25

   Method of manufacturing individual microlenses on a rear projection screen sheet in register with apertures provided in a contrast-enhancing light absorbing layer, by successively printing on the sheet a plurality of patterns, each one registering with the previous pattern but having a different extension so as to form a three-dimensional printed structure constituting said lenses.

4. Claims: 15, 26

   Method of manufacturing individual microlenses on a rear projection screen in register with apertures provided in a contrast-enhancing light absorbing layer, by applying on the sheet droplets of molten light transmitting resin by means of a computer controlled printing device.

1. The common subject matter of the independent claims is already known from document D1 (US 1 942 841 A, see fig. 1), which discloses a rear projection screen having a transparent sheet (1), a plurality of individual lenticular bodies of light transitting material (2) adhered thereto, and a contrast-enhancing light absorbing coating (5') adhered to the sheet (1), said coating comprising an array of apertures (5) registering with said lenticular bodies (clear from the passage in page 1, lines 104-111).

The lenticular bodies of D1 have to be regarded as being "individual" bodies in the meaning of the application, in the light of the passage

in page 2, lines 88-105 of D1, which explains that the lenticular bodies can be realised as a piled superposition of two gratings of cylindrical lenses, wherein each of said lenses is in the form of a glass rod.

It is clear from the teaching of D1, that realising the lenticules with arrays of glass rods would replace the operation of molding the lenticules on the transparent sheet (see page 1, lines 45-46 and page page 2, linse 80-83). That is, the lenticular bodies may be realised either by molding them on one side of a transparent sheet or by attaching to the sheet a pile of two gratings of glass rods.

2. The teaching of document D1 entirely corresponds to the subject matter of independent claims 1 and 6. Moreover, document D1 discloses also the features of dependent claims 2, 4 and 5 (for claim 2 see fig. 1, lenticules and light absorbing coating on opposite sides of the sheet; for claims 4 and 5 see asymmetrically diffusing layer 6, page 1, lines 109-111 and page 2, lines 46-58).

Therefore, the first claim defining novel subject matter is claim 3.

3. Having regard to the above, the claims have to be cast in the following groups of inventions:

i. Claims 1-6 and 17, which relate to a rear projection screen having lenticular lenses and apertures in the light absorbing coating of a particular shape, namely cylindrical lenses and apertures in the form of continuous slots.

ii. Claims 7-12 and 18-23, which relate to the manufacture of lenticular lenses by providing on a transparent sheet spots which are wettable by a polymer, said spots being serrounded by a surface which is not wettable by said polymer.

iii. Claims 13-14 and 24-25, which relate to the manufacture of lenticular lenses by successively printing on a sheet a plurality of patterns, each one registering with the previous pattern but having a different extension so as to form a three-dimensional printed structure constituting said lenses.

iv. Claims 15 and 26, which relate to the manufacture of lenticular lenses by applying on a sheet droplets of molten light transmitting resin by means of a computer controlled printing device.

4. Therefore, the above groups of claims do not share any common or corresponding special technical feature which would link them so as to form a single inventive concept (Rules 13(1) and 13(2) PCT).

INTERNATIONAL SEARCH REPORT

Information on patent family members

Interna... ...al Application No
PCT/GB 99/00085

Patent document cited in search report		Publication date	Patent family member(s)			Publication date
US 1942841	A	09-01-1934	NONE			
US 5563738	A	08-10-1996	AU	7682994	A	22-03-1995
			EP	0716754	A	19-06-1996
			JP	9504882	T	13-05-1997
			WO	9506888	A	09-03-1995
			US	5781344	A	14-07-1998
US 4927233	A	22-05-1990	NONE			
JP 02266301	A	31-10-1990	NONE			